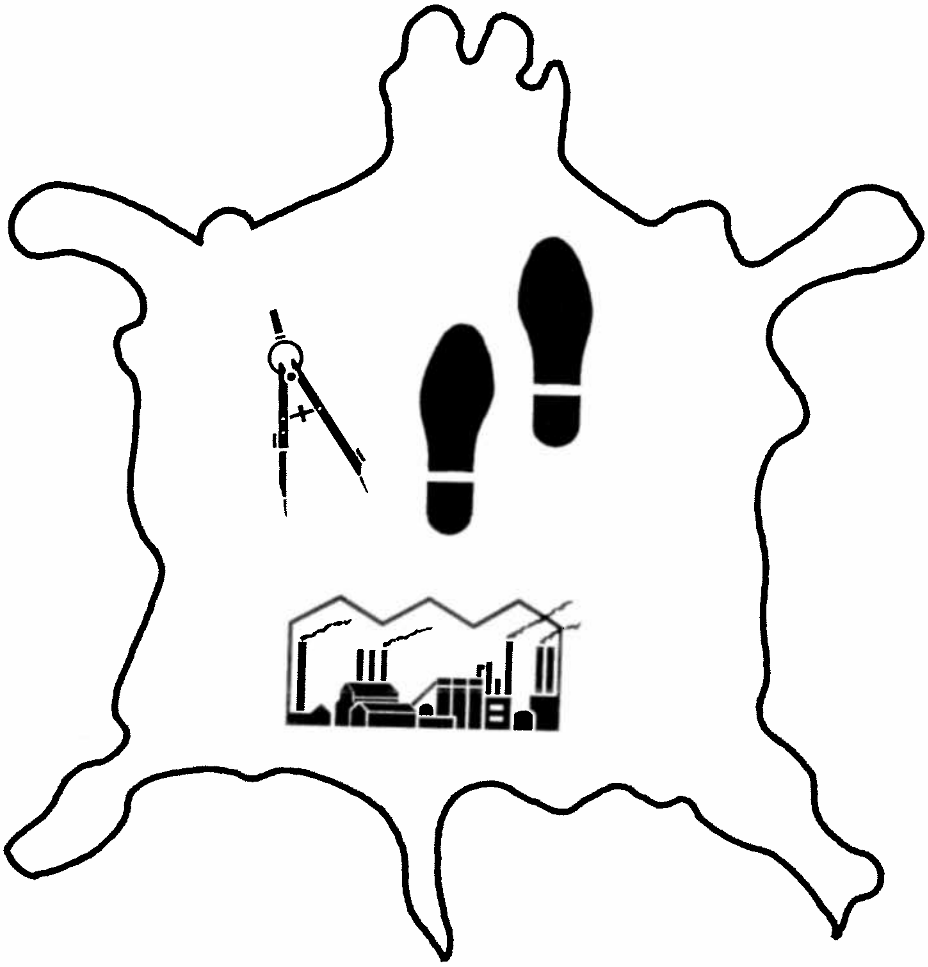
SHOE INDUSTRY
CERTIFICATE COURSE

UNIDO

ELEMENTS OF CHEMISTRY*



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This learning element was developed by the UNIDO Leather Unit's staff, its experts and the consultants of the Clothing and Footwear Institute (UK) for the project US/PHI/85/109 and is a part of a complete Footwear Industry Certificate course. The material is made available to other UNIDO projects and may be used by UNIDO experts as training aid and given, fully or partly, as hand-out for students and trainees.

The complete Certificate Course includes the following learning elements:

Certificate course

-Feet and last
-Basic design
-Pattern cutting
-Upper clicking
-Closing
-Making
-Textiles and synthetic materials
-Elastomers and plastomers
-Purchasing and storing
-Quality determination and control
-Elements of physics
-General management
-Production management
-Industrial Law
-Industrial accountancy
-Electricity and applied mechanics
-Economics
-SI metric system of measurement
-Marketing
-Mathematics
-Elements of chemistry

FOOTWEAR AND LEATHERGOODS INDUSTRY CENTER

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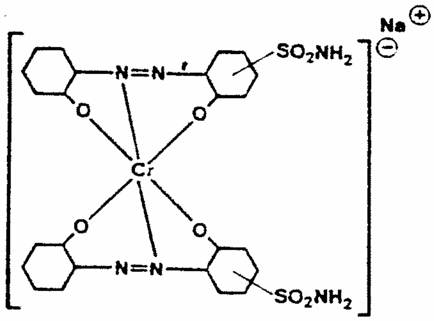

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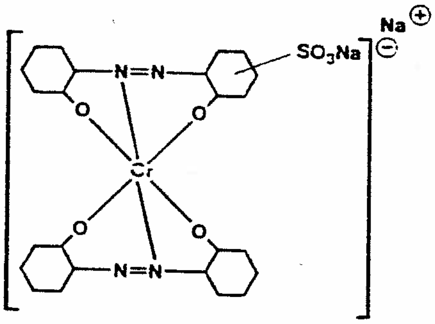

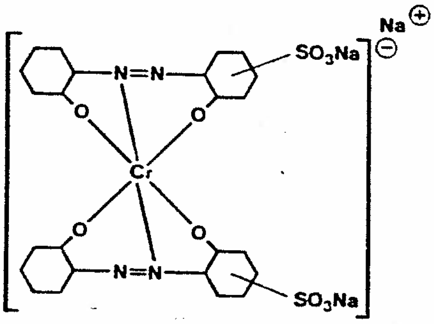

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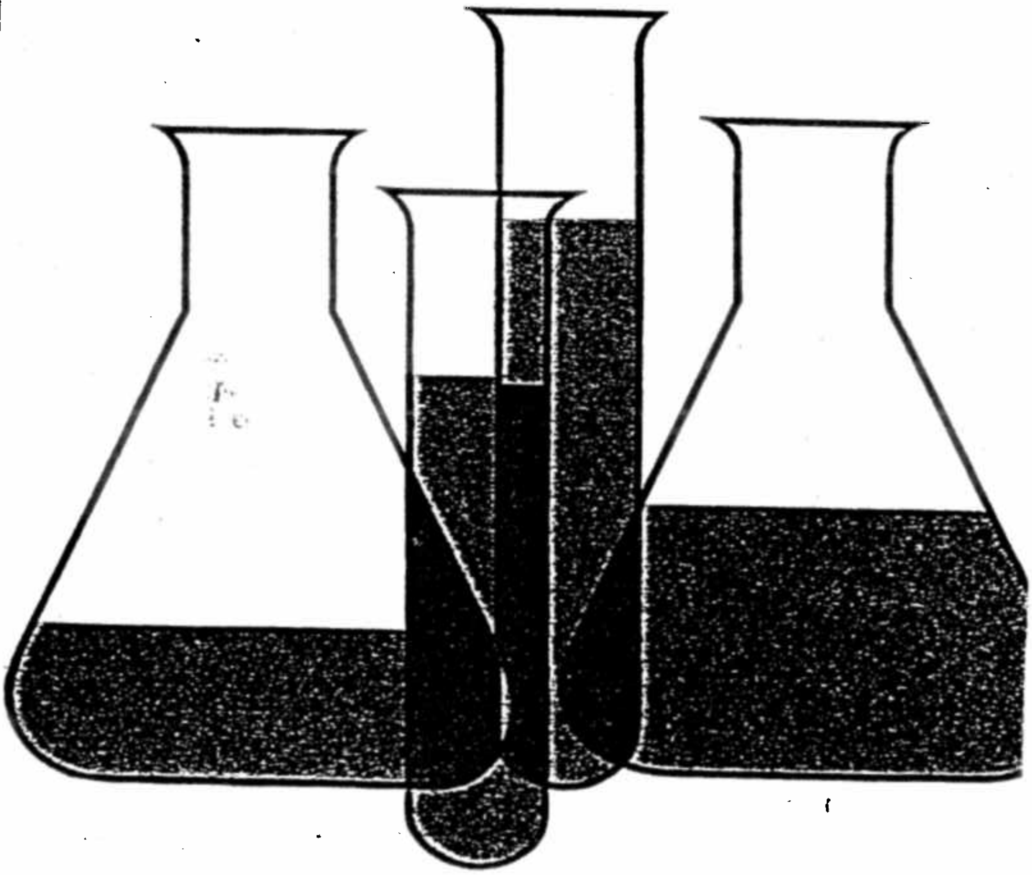

ELEMENTS OF CHEMISTRY

Table of content

Principles of Chemistry

I. ATOMS AND MOLECULES

1. SCIENCE is a method of explaining the facts of nature.

   By facts of nature we mean those phenomena observable by man's senses: night and day, the falling of an unsupported object, sickness and death, behaviour of water, sugar, etc.

   As the number of facts known to science is very high, we have a great number of divisions of science: astronomy, physics, biology, chemistry and many more.

2. CHEMISTRY is the science which deals with the changes which matter undergoes. Chemistry deals with such things as burning of coal where coal undergoes a change from its original form to ashes and gases or the changed of hide into leather or the change of latex into rubber.

3. MATTER is anything which possesses mass, or more simply, anything which has weight and occupies space. In other words, matter is any material objects. Such things as electricity, heat, light, sound since they do not have weight are not matter. Water, salt, air have weight and are matter.

   Matter is composed of particles. We can divide matter (example: one kilogram of water in grams, milligrams, microns). But matter cannot be cut up indefinitely as there is a limit. That limit is extremely small and is called molecule.

4. MOLECULES

   All matter is composed of tiny particles called the molecules. These we cannot divide without destroying the matter. Each kind of matter is composed of molecules. Water has one kind of molecules, sugar has different kind, sulfuric acid has still different kind, and so on through all the pure substances. There are millions of different kinds of molecules, but all molecules of the same substance are the same. All water molecules are alike, all sugar molecules are alike.

5. ATOMS

   If we don't mind destroying the material, there are ways of dividing molecules. If we treat water with an electric current we can divide the molecules but we destroy the water and get in its place two gases: Hydrogen and Oxygen. This process is sort of like dividing a group of people.

   We can divide it up into two, four groups until down to one person. We can divide further but the result will not be a person but arms, legs, etc.

Molecules are made up of something smaller and these smaller units are called atoms. The atoms like the arms or legs have no separate existence. They are part of molecules but can exist only when combined into molecules.

If there are millions of different kinds of molecules, there are only a few over 90 different kinds of atoms and all the millions of kinds of molecules are made by different combinations of the few atoms.

Two kinds of molecules will be immediately obvious: those of all the same kind of atoms, and those made up of different kinds. Water has two kinds of atoms, oxygen has only one kind.

6. ELEMENTS

When all the atoms in a molecule are alike, we call that molecule an element. This means that there can be only around 90 elements. Some elements are plentiful on the earth and important to the industry, some are scarce. Iron, sulfur, oxygen, copper, carbon, chlorine, silver and gold are examples of elements that are plentiful. Krypton, inidum, neodymium are rare.

7. COMPOUNDS

When the atoms which make up a molecule are more than one kind, we call the resulting substance a compound. The number of possible compounds is infinite, new ones are being made every day, e.g. nylon, plastics. Compounds may be composed of two kinds of atoms or of many. Water is composed of two kinds: oxygen atom and hydrogen atom, sulfuric acid is composed of three different kinds of atoms: hydrogen, sulfur and oxygen.

8. MIXTURES

It is possible to mix molecules e.g. sugar and water. These substances are called mixtures. They may be mixture of compounds or mixtures of elements. Air is a mixture of oxygen and nitrogen molecules, both are elements, sugar and water is a mixture of compounds.

Many substances are really mixtures, they are composed of more than one kind of molecules without chemical reaction between them e.g. sugar and sand, pigment and rubber. The molecules of a mixture lie side by side without affecting each other.

SUMMARY

CHEMISTRY	:	the science of matter and its changes
MATTER	:	anything that has weight
MOLECULES	:	smallest particle of matter
ATOMS	:	building blocks of molecules. No separate existence.
ELEMENTS	:	substances whose molecules contain only one kind of atoms Often 2, 4 or 8 atoms per molecule.
COMPOUNDS	:	substances whose molecules contain more than one kind of atoms. Sometimes only two kinds, sometimes a dozen or more kinds.
MIXTURES	:	substances composed of more than one kind of molecules.

II. SYMBOLS AND FORMULAS

1. CHEMICAL SYMBOLS

To facilitate interpretation and writing of chemical information, an universally adopted method is available. Each atom is represented by the initial letter or letters of its Latin name, e.g.

C stands for one atom of Carbon
O stands for one atom of Oxygen

When more than two elements have the same initial letter, the second or another letter are used to distinguish

Cl for chlorine
Cr for chromium
Cu for copper (cuprum)

so F will be Fluorine and Fe will be Iron (Ferrum)
N will be Nitrogen and Na will be Sodium (Natrium)
H = Hydrogen
He = Helium
Hg = Mercury (Hygrarium)

2. CHEMICAL FORMULAS

Each symbol represents one atom. If we write two symbols together, they represent a molecule, the chemical union of two atoms.

For instance carbon monoxide is a molecule composed by one atom of carbon and one atom of oxygen, we will write it CO

Common salt is madè of one atom of sodium and one atom of chlorine, its formula is NaCl

Some molecules contain more than two atoms, we represent this by writing all the atoms side by side. Laundry bleach (chlorox) is made of sodium, chlorine and oxygen atoms, its formula is NaClO

When an atom appears more than once in a molecule, we indicate the number of times it appears by writing a subscript after its symbol, as in water which is made of two atoms of hydrogen and one of oxygen, its formula is H_2O. Sulfuric acid is H_2SO_4 Sodium bicarbonate $NaHCO_3$

It is interesting to note how much the properties change when chemical combination takes place. Carbon is a black solid, oxygen is a colorless gas, the essential constituent of air. But carbon monoxide CO is a colorless poisonous gas.

Sodium is a soft silvery metal which catches fire when put with water. Chlorine is a green, evil smelling, poisonous gas. But their chemical union NaCl is common salt. This complete change of properties is usual when elements combine to form new molecules.

The elements are molecules containing only one kind of atom (see I) Oxygen is O_2 Chlorine is Cl_2 Sulfur is S_8 and Phosphorus is P_4

3. ATOMIC WEIGHTS

One of the properties characteristic of an atom is weight. Each atom has a particular weight characteristic of that atom. Of course the actual weights are extremely small, too small to be of practical use, but by assigning a practical size weight to each atom, relative weights are determined which tell us how much heavier one atom is than another. Oxygen is chosen as the standard for these atomic weights. It is assigned the number 16. Cards and tables give the relative weight or atomic weight of each atom.

4. MOLECULAR WEIGHTS

If we add up the weights of all the atoms in a molecule, we get the relative weight of the molecule or molecular weight.

Noting that Carbon has atomic weight 12 and Oxygen 16, we see that the molecular weight of CO is 28.

Likewise for sulfuric acid, H_2SO_4 we get:

H	2 x 1	=	2
S	1 x 32	=	32
O	4 x 16	=	64
			98

The atomic weight of Oxygen is 16, its molecular weight is 32 because the molecule of Oxygen is O_2

5. VALENCE

Atoms combine to form molecules because they have combining power or chemical affinity. Valence is a measure of the combining power of an atom.

The unit of combining power - valence - is the combining power of Hydrogen. When an element combines with one Hydrogen, we say it has a valence of one, when it combines with two hydrogen its valence is 2, etc.

Oxygen has valence 2 (H_2O), Nitrogen is 3 (NH_3 ammonia) and Carbon is 4 (CH_4 Methane)

A knowledge of valence is most convenient for it allows to write formulas without remembering them.

<u>SUMMARY</u>

SYMBOLS : each element represented by a letter symbol which stands for one atom of that element

FORMULAS : when atoms combine to form molecules, we write the symbols side by side, indicating presence of more than one of a particular atom by the appropriate subscript.

ATOMIC WEIGHTS : the relative weight of the atom with Oxygen assigned the value 16.

MOLECULAR WEIGHTS : the sume of the atomic weights of all the atoms in a molecule

VALENCE : the measure of the combining power of the atoms, Hydrogen taken as unity

III. SUBDIVISIONS OF CHEMISTRY SCIENCE

There are two main subdivions in the Chemistry :

1. The Inorganic Chemistry or Mineral Chemisty
2. The Organic Chemistry or Carbon Chemistry

The elements of mineral chemistry are divided into two large classes:

the metals and the non-metals (metaloides)

METALS are those elements having the usually acknowledged metallic properties of luster, high melting point, conductivity of heat and electricity, malleability, ductility, etc.

NON-METALS lack these properties. They are liquids, gases and some solids.

OXYGEN is the most important non-metal. It is a colorless, odorless gas which constitutes one-fifth of the volume of air. It is also present in most minerals and many organic compounds. It is the most abundant of all the elements.

It is important for two reasons:

1. It is the usual cause of combustion.
2. Its compounds, the oxides, are the basis of so much of inorganic chemistry.

OXYDATION and COMBUSTION

The process of combining a substance with oxygen is called oxidation. During oxidation energy is usually given out. Sometimes this energy is given out in large amounts. If conditions are arranged so that the process takes place rapidly, heat and light are evident and we say the substance burns, COMBUSTION takes place.

Three conditions are necessary for combustion to occur:

1. A substance to burn
2. A source of oxygen
3. The temperature must be raised to a point where the reaction goes on rapidly. This is called the kindling temperature.

Combustion is a type of oxidation. Not all oxidation is combustion though. The rusting of iron is oxidation but it does not take place rapidly enough to be classed as combustion. Oxidation can occur on rubber, thats why adhesive must be applied immediately after roughing.

OXIDES are the resulting product of oxidation. The properties of oxides are very important. Most oxides can be made to combine with water by direct mixing or by indirect means.

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If the oxide is that of a metallic element, its compound with water is a BASE or ALKALI.

example : lime is the oxide of Calcium CaO (calcium oxide) when we put with water, we have

$$CaO + H_2O = Ca(OH)_2$$

If the oxide is that of a non-metal we get an ACID

$$SO_3 + H_2O = H_2SO_4$$

When acids and bases combine, they eliminate water and another compound called a SALT is formed.

$$Ca(OH)_2 + H_2SO_4 = CaSO_4 + 2H_2O$$

Other non-metals are chlorine, iodine, sulfur, nitrogen, etc.

Metals are namely Sodium, potassium, calcium, iron, chromium, aluminum etc.

SUMMARY

Elements are divided into metals and non-metals

METALS have metallic physical properties and their oxides produce BASES when combined with water.

NON-METALS do not have metallic properties and their oxides produce ACIDS when combined with water.

OXYGEN : colorless, odorless gas
present in air and many other substances
most abundant element
produces the oxides

SALTS : combination of acid and base.

IV. CHEMICAL REACTIONS

When two substances react together, a chemical reaction occurs resulting to a chemical change and rearrangement of atoms.

For instance, what happen when charcoal burns in air?
Consider charcoal as pure carbon and take only one of the constituents of air : Oxygen.

$$C + O_2 = CO_2 \quad \text{carbon dioxide}$$

In the reaction, no new atoms is produced nor lost merely rearrangement of the atoms. This is perfectly general and universal. Chemical reactions, no matter how it occured, are never anything but rearrangements of atoms.

Law of Conservation of Matter

In a chemical reaction, matter is neither created nor destroyed. The sum of the weights of the reactions exactly equals the sum of the weights of the products.

Rules of Reactions

1. Metals, hydrogen and the NH_4 radical are called positive (+)
2. Non-metals, acid radicals and oxygen are called negative (-)
3. In general, reaction occurs between + and - , not between 2^+ or 2^-
   There are exceptions (non metal with an oxide)
4. The positive part of a compound is written first in the formula

Chemical Arithmetic

Deriving from the atomic and molecular weights, reaction can be written in an arithmetical equation.

Not only that it can be predicted from chemistry what substances would be the results but also how much they would be.

Hydrogen	+ Chlorine	=	Hydrogen Chloride or Hydrochloric acid
H_2	+ Cl_2	=	$2HCl$
(2×1)	+ (2×35.5)	=	2×36.5
2	+ 71	=	73

To determine how much lime can be produced from limestone (CaCO3), add the atomic weights of the reaction

$$CaCO3 + \text{Heat} = CaO + CO_2$$

Ca	40	Ca	40	C	12
C	12	O	16	2 x O	32
3 x O	48				
	100		56		44

The molecular weights can be extrapolated in any other unit.

SUMMARY : CHEMICAL REACTION = chemical change = rearrangement of atoms

V. SOLUTIONS

A solution is a "homogeneous" mixture of two or more substances.

By homogeneous we mean we find all parts exactly alike.

This is not true in an ordinary mixture (sand and salt)

SOLVENT is one component of the solution, usually present in larger quantity. It seems to act as the dissolving medium.

SOLUTE is the material which disappears or dissolves.

When a solid dissolves in a liquid, there is no difficulty in determining that the liquid is the solvent and the solid the solute.

However, when a liquid dissolves in another, the distinction between solvent and solute can no longer be made so easily. There is really no difference which we call solvent and which solute. Usually when one is present in large quantity and the other in small quantity, that in large quantity is called solvent and the less plentiful is considered the solute.

We are much more familiar with liquid solutions than with any other kind. However, we may have solutions which are gas, liquid or solids.

Liquid solutions :	Soda water	Solute CO_2 (gas)	Solvent water
	Sea water	Solute salt (solid)	Solvent water
	Wine or Liquor	Solute alcohol (liquid)	Solvent water
Gaseous solutions :	Air (dry)	Oxygen in Nitrogen	(gas/gas)
	Air (moist)	Water in air	(liquid/gas)

Examples of solids dissolved in gas are hard to find
moth ball (solid/gas/gas)

gas in solid: carbon monoxide in red hot Iron

liquid in solid solution occurs when leather picks up moisture.

Solid solutions : most of the alloys

The strength of a solution is expressed in units of weight per volume or in per cent, sometimes in density.

True solutions have the solute dispersed as individual molecules or ions (see VI)

Colloidal solutions are solutions in which multiple molecules are dispersed (association) e.g. soap, dyes

SUMMARY		
	Solution	homogeneous mixture of two or more substances
	Solvent	the dispersing medium of a solution
	Solute	the dispersed substance of a solution

VI. IONIZATION

Certain atoms, when they combine, become electrically charged. In this charged condition, they are known as IONS.

For example, when sodium and chlorine combine to form sodium chloride, the sodium atom becomes positively charged and the chlorine becomes negatively charged. The amount of positive and negative charge is equal, so the salt appears neutral.

It is this charged which holds the sodium and chlorine together. Unlike charges attract so that the two ions are held together.

When ionizing substances are dissolved, it is the ions which form the entities in solution. Sodium chloride solution contain Na^+ and Cl^- but no NaCl.

ELECTROLYSIS is an application of ionization. (see note)

When a solution containing ions is mixed with a solution containing different ions, all ions of unlike charge attract each other, but if one of the combinations is insoluble it will precipitate.

e.g. N aCl + $AgNO_3$ gives a precipitate of AgCl

ACIDS are a class of compounds related to true electrolytes but quite individual in behavior. They react chemically with water and few other solvents to give ions

$$HCl + H_2O = H3O^+ + Cl^-$$

The properties associated with an acid are those of the hydronium ion H_3O (sour taste, red reaction with litmus, reaction with bases). For convenience whenever we refer to the acid ion we will shorten it to $H+$.

WATER is a molecular substance which ionize a little, but this little is of great importance,

$$2H_2O = H_3O^+ + OH^- \quad (H^+ + OH^-)$$

One important characteristic of ionization of water is that the product of the concentration of hydronium ions and the hydroxide ions is a constant:

$$(\text{conc. } H_3O^+) \times (\text{conc. } OH^-) = 0.000\ 000\ 000\ 000\ 01$$

$$\text{or} \quad \frac{1}{100{,}000{,}000{,}000{,}000}$$

$$\text{or} \quad \frac{1}{10^{14}}$$

or one hundred trillienth

Since the number of H_3O^+ and of OH^- in pure water is the same, we will have

$$\text{conc of } H_3O^+ = \frac{1}{10^7}$$

$$\text{conc of } OH^- = \frac{1}{10^7}$$

Now if we add acid to water it will ionize, this means that a lot of H_3O^+ ions are added to the water but no OH^-

If we add an alkali to the water we will add OH^- ions and no H+

but the value of the concentration will always adjust to $\frac{1}{10^{14}}$

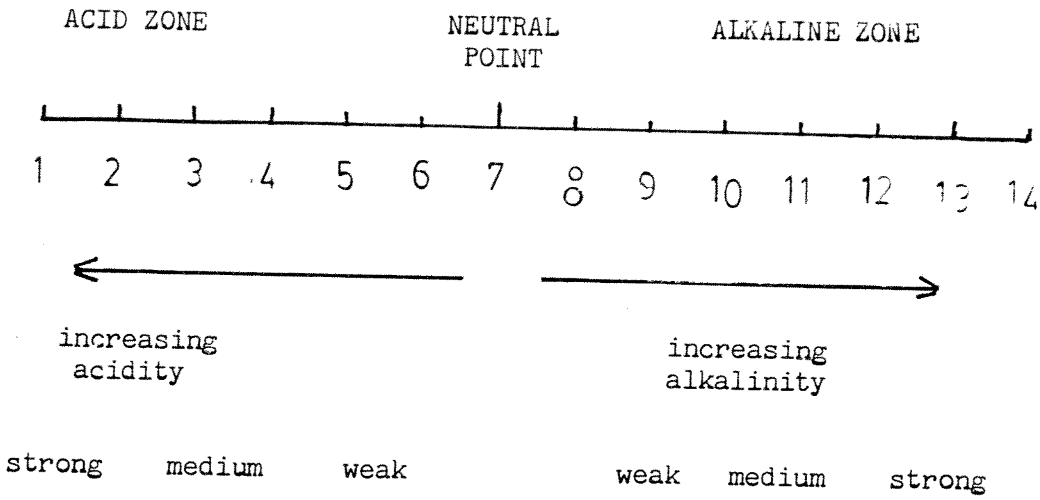
Since the concentration of the H_3O^+ and OH^- is related with presence of acid or alkali in water, a simplified scale of indicating it has been perfected

This scale is called pH scale and it works like this:
A solution is said to have a pH value which is the value of the exponent of ten in the denominator of the fraction representing its concentration

A neutral solution is one where the concentration of H^+ equals the concentration of OH^- and this can only be true when they are both equal to $\frac{1}{10^7}$ The pH of a neutral solution is therefore 7

If the solution is acid the concentration of H^+ will be higher than the concentration of OH^- so the exponent will be a number smaller than 7. For pH 2 the concentration of H^+ will be $\frac{1}{10^2}$ pH 3 $\frac{1}{10^3}$ etc.

If the solution is alkaline, the concentration of H^+ will be smaller than that of OH^- so the exponent will be a number larger than 7 pH 10 $= \frac{1}{10^{10}}$



The pH scale is not an additive scale like in a ruler.

Each unit corresponds to 10 times more or less acidity or alkalinity to the next pH unit.

pH	5 is	10	times more acid than pH 6
pH	4 is	100	times more acid than pH 5
pH	3 is	1000	times more acid than pH 4
pH	2 is	10000	times more acid than pH 3
pH	1 is	100000	times more acid than pH 2

SUMMARY

IONS are charged atoms or radicals

ELECTROLYSIS : the passage of current through an ionizing solution and the breaking up of the substance into its elements.

ACIDS are molecular substances which react with water to produce hydronium ion H_3O^+

PURE WATER may be considered as a very weak acid.

The product of the concentration of H_3O^+ X concentration of OH^-

is constant and equal to $\frac{1}{10^{14}}$

pH is a short method of indicating concentration of hydronium ions.

NOTE

ELECTROLYSIS

If wires connected to a battery are dipped into an ionizing solution, these wires will take on a charge from the battery. Since unlike charges attract, the positive ions of the solution will be attracted to the negative wire, and the negative ions will be attracted to the positive wire.

Let us suppose two platinum wires with one end of each attached to a battery and the other end dipped in a solution of copper chloride $Cu\,Cl_2$. This solution is that of a salt and hence a mixture of Cu^{++} and Cl^-, twice as many Cl^- as Cu^{++}. The negative wire will attract to it the Cu^{++} ions. When they touch the wire, which is negatively charged, they will have their positive charges neutralized. They will become copper and this copper will plate out on the wire. In the mean time, negative Cl^- ions have been attracted to the positive wire. There they are neutralized (loss their negative charge) and becomes chlorine. But chlorine is a gas and as it plates out on the wire it forms bubbles.

Applications of electrolysis in silver and gold plating, also in metallization of heels and accessories.

VII. ORGANIC CHEMISTRY

Up to a century ago, substances of animal or vegetable origin were classed as "organic." It was believed that organic compounds had some kind of "vital" or "life force."

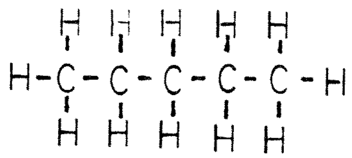
When it became possible to synthesize organic compounds (urea, acetic acid, alcohol, etc.) this was no more true.

We call "organic" chemistry the chemistry of CARBON compounds.
The fundamental laws of chemistry apply to organic chemistry with equal force as for inorganic chemistry but, organic chemistry will have typical characteristics, namely:

1. High number of compounds, more than 500,000 for compounds containing carbon againstsome 75,000 for inorganic compounds.

2. In general, organic and inorganic compounds show marked differences in solubility.

3. The atoms of carbon have the unique property of combining with one another to form chain like structures, for example:



4. Organic compounds are, as a rule, less stable than inorganic; they are much more easily susceptible to chemical and physical changes. Organic compounds are decomposed at relatively low temperatures.

5. "type" reactions are quite frequent in organic chemistry. For example, there are hundreds of compounds which reacts with nitric acid to give "nitro" compounds, the same with reducing agents to form "amino" compounds.

6. There is often a marked difference in the velocity of reaction. The change of one organic compound to another is usually slow.

7. Reactions in organic chemistry are, as a rule, mostly non-ionic, the solutions being non-conductors of electricity.

   However, organic acids, bases and salts do ionize but to a much lesser degree than their inorganic counterparts.

8. Reactions in organic chemistry often tend to become quite complex and there are possibilities of many "side" or "secondary" reactions.

9. The complexity in structure exhibited by some organic compounds is quite unknown among inorganic compounds

10. Organic compounds often show a property called "isomerism." (See IX,)

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SOURCES OF ORGANIC COMPOUNDS

1. Organic compounds may be traced either to the plant or animal kingdom. Out of water, carbon dioxide and various constituants of the soil, in the presence of light, the plant build up a very large number of substances : sugar, starches, cellulose, alkaloids (morphine nicotine), acids, salts, esters, dyes (logwood, indigo) and tannins.

2. Plants and animals furnish us with fats, proteins, carbohydrates, enzymes, vitamins.

3. Destructive distillation of coal (destruction by heat in the absence of air) gives coal gas, ammonia, coke and coal tar.

   Coal tar is the starting point for number of organic products such as toluene, benzene, naphtalene, cresols, etc.

4. Destructive distillation of wood yields acetic acid, methanol, acetone gases, charcoal.

5. Destructive distillation of bones yields bone black and bone oil which yields a large number of nitrogeneous compounds

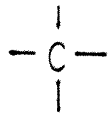
6. Fractional distillation of petroleum gives such products as naphta, gasoline, kerosene, gas oil, lubricating oil, vaseline etc.

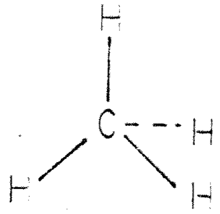
7. Fermentation, e.g. conversion of sugar into alcohol under working of substances known as "enzymes."

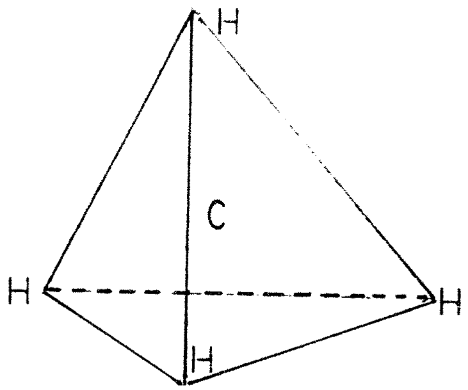
8. Putrefaction or decomposition of animal or vegetable substances by microorganisms.

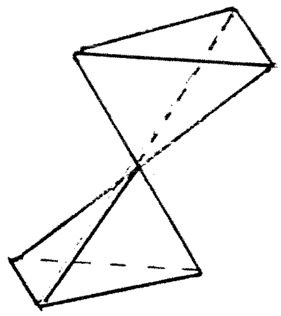
VIII. Structural Theory of Organic Chemistry

1. The valence of Carbon is four and is represented as:







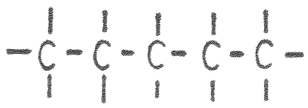


where any one bond bears exactly the same relationship to the carbon atom as any other bond. These valencies may be represented as directed towards the corners of a regular tetrahedron, constructed around the carbon atom as a center, and are, therefore, equidistant from each other in space.

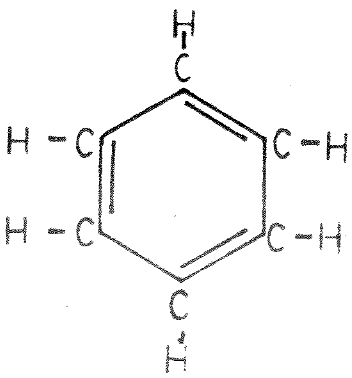
2. Carbon atoms may be united either by single, double or triple bonds.

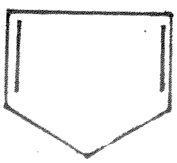
C−C C=C C≡C

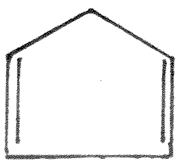
3. Carbon atoms may form a straight chain



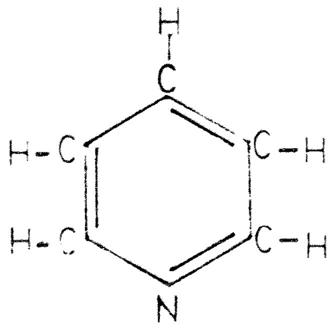
4. Carbon atoms may form a "closed" Chain

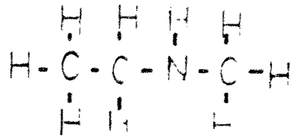




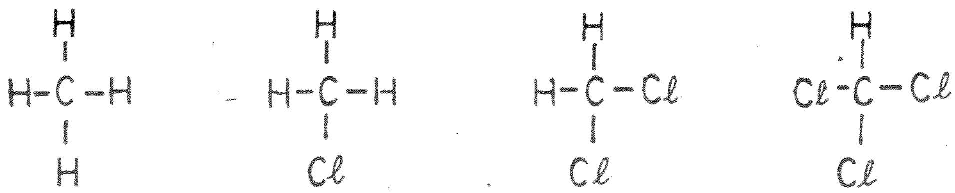


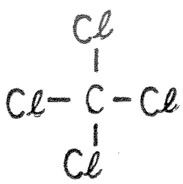
5. Other elements besides carbon may enter a carbon chain or ring





6. Elements may substitute one another in compounds; that is, one element in a compound may be removed, and another may take its place.





IX. Classes of Organic Compounds

There are so many organic compounds that for purposes of study they must be divided into groups.

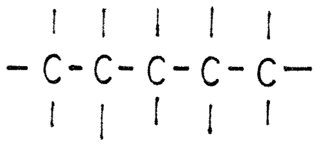
Based on chemical structure and reactions, two main groups of organic compounds are recognized:

1. the aliphatic ompounds or non-benzoids
2. the aromatic compounds or benzoids

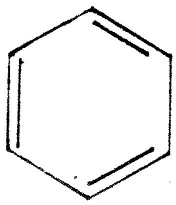
The dividing line between the two classes is not always a sharply drawn.

The compounds of each group are subdivided into several classes of compounds.

In aliphatic compounds the carbon atoms are commonly linked together in a chain



In aromatic compounds, the carbon atoms are joined in a ring.



ALIPHATIC COMPOUNDS

1. Hydrocarbons

   1.1 Saturated hydrocarbones (alkanes) "ANE" Methane serie parafines

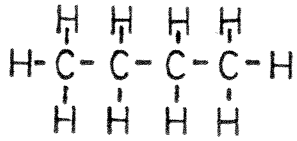
   see tabel 1.

ISOMERISM

When there are one, two or three Carbons, there is only one kind of display of the atoms around the Carbon.

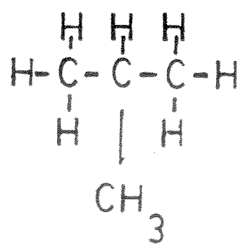
But, when we come at four Carbons and over there can be more kinds of display of the atoms around the Carbon.

C_4H_{10} can be



butane

or iso-butane

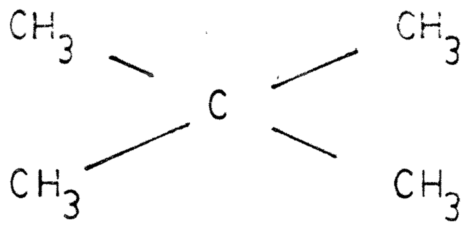


and C_5H_{12} can be $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

or

$$\begin{array}{l} CH_3\text{-}\underset{\displaystyle |}{C}H\text{-}CH_2\text{-}CH_3 \\ \quad\;\; CH_3 \end{array}$$

or



Different compounds that have the same molecular formula but a different display of the atoms in the structural formula are called ISOMERS

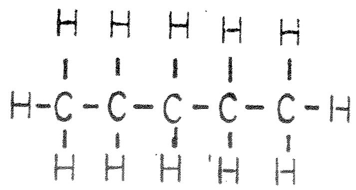
Tabel 1.

SATURATED HYDROCARBONS   Alkanes   Parafines

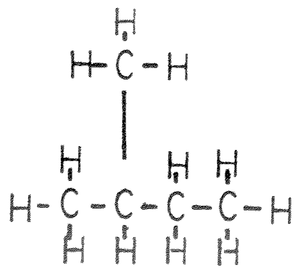
BOILING POINT
DENSITY

Methane	CH_4			GASES
Ethane	C_2H_6	CH_3CH_3		
Propane	C_3H_8	$CH_3CH_2CH_3$		
Butane	C_4H_{10}	$CH_3CH_2CH_2CH_3$	Isobutane $(CH_3)_2CHCH_3$	
Pentane	C_5H_{12}	Isopentane $(CH_3)_2CHCH_2CH_3$		LIQUIDS
Hexane	C_6H_{14}	Isohexane $(CH_3)_2CHCH_2CH_2CH_3$		
Heptane	C_7H_{16}	Isoheptane		
Octane	C_8H_{18}	Isooctane		
Nonane	C_9H_{20}	Isononane		
Decaner	$C_{10}H22$	Isodecane		
Hexadecane	$C_{18}H38$			SOLIDS
Tetracosane	$C_{24}H50$			
Hexacontane	$C_{60}H122$		$C_n H_{2n+2}$	

PENTANE

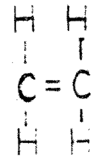
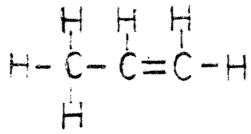


ISOPENTANE



UNSATURATED HYDROCARBONS

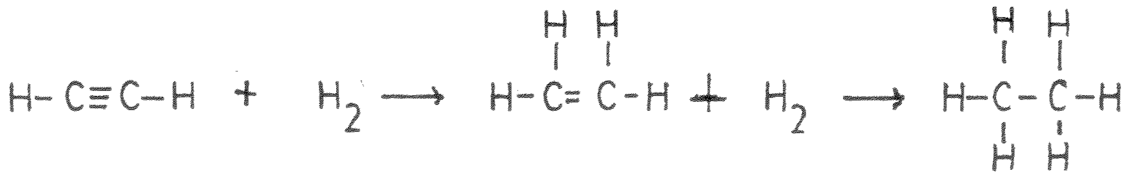
ALKENES or OLEFINES

ETHYLENE	ETHENE	$CH_2 = CH_2$	
PROPYLENE	PROPENE	$CH_3\text{-}CH = CH_2$	
BUTYLENE	BUTENE	$CH_3\text{-}CH_2\text{-}CH = CH_3$ or $CH_3\text{-}CH = CH\text{-}CH_3$	
ISOBUTYLENE	Methylpropene	$CH_2 = C\ (CH_3)_2$	

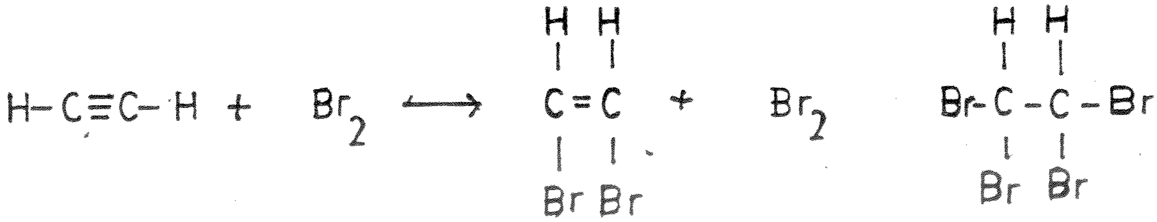
ALKINES or ACETYLENE

ACETYLENE	ETHINE	$H-C\equiv C-H$

Since acetylene is more unsaturated than ethylene, it can add to itself more atoms.



ethylene ethane



Acetylene dibromide tetrabromoethane

1.2 Unsaturated hydrocarbones (alkenes) "ENE" Ethylene serie olefines

Ethene or Ethylene	$CH_2 = CH_2$
Propene or propylene	$CH_3 - CH = CH_2$
Butene or butylene 1.	$CH_3-CH_2-CH = CH_2$
Butene or butylene 2.	$CH_2-CH = CH-CH_3$

Ethylene is a monomer, from the Greek mono = one, mer = part, a small molecule.

The union of monomers will give a big molecule, a macromolecule, called a POLYMER.

Ethylene $CH_2=CH_2$ under influence of an initiator and in given conditions of temperature and pressure will give a polymer POLYETHYLEN

$$n\ C_2H_4 \xrightarrow[AL\ Cl_3]{130^\circ C\ /\ 60\ atm} \longrightarrow (C_2H_4)_n + x\ kcal \qquad (liquid)$$

$$n\ C_2H_4 \xrightarrow[O_2]{200^\circ C\ /\ 1000\ atm} \longrightarrow (C_2H_4)_n \qquad (solid)$$

$$n\ C_2H_4 \xrightarrow[org.Al\ \ TiCl_4]{151^\circ C\ /\ 50\ atm} \longrightarrow (C_2H_4)_n \qquad (solid)$$

Butene or Butylene Butadiene

$CH_3-CH_2-CH = CH_2 \quad \xrightarrow{Cr_2O_3Al_2O_3} \longrightarrow CH_2=CH-CH=CH_2 + H_2$

chain + initiator $\longrightarrow$ elastomer BUNA (butadiene natrium)

+ Styrene BUNA S

X. ALCOHOLS

The alcohols are a very important class of compounds to the organic chemistry, they are also very important to the industry, many uses have been found for them. They are intermediates in one process of making synthetic rubber and they are also an excellent fuel.

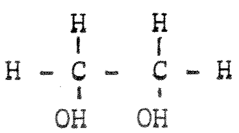
The alcohols may be considered as hydrocarbons in which one or more of the hydrogens are replaced by OH groups. They may also be regarded as derived from water in which one of the hydrogen is replaced by R

H - OH R - OH

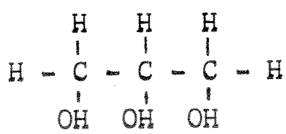
The relationship of the hydrocarbons to the alcohols is easily shown.

methane	CH_4 or CH_3H	CH_3OH	methanol	
ethane	C_2H_6	C_2H_5OH	ethanol	
propane	C_3H_8	C_3H_7OH	propanol	
Alkane	RH	ROH	alkanol	alkyl alcohol

Alcohols may contain more than one OH group provided they are attached to different carbon atoms :

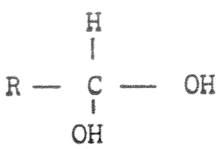


glycol



glycerol

Two or more OH groups attached to the same carbon give rise to, as a rule to unstable compounds.



aldehyde

Properties of alcohols

1. Depending on the location of the OH group, alcohols are oxidized to: aldehydes

   ketones

   acids (see table)

2. Sodium reacts with alcohols to give ALCOHOLATES

   $2\ C_2H_5OH + 2\ Na \longrightarrow 2\ C_2H_5ONa$ sodium ethylate or alcoholate

3. Alcohols combine with acids to form ESTERS

$$C_2H_5OH + \underset{\text{acetic acid}}{CH_3 - \overset{\overset{\large O}{\|}}{C} - OH} \qquad \underset{\text{ethyl acetate}}{CH_3 - \overset{\overset{\large O}{\|}}{C} - C_2H_5OH}$$

ETHERS

Ethers may be considered as derived from alcohols in which the H of the ROH is replaced by an R group. $R - O - R$

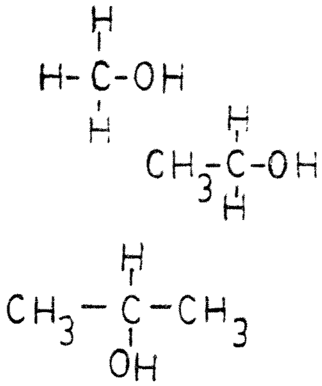
They may also be looked upon as derived from water HOH in which both hydrogens are replaced by R groups.

The ethers are really organic oxides.

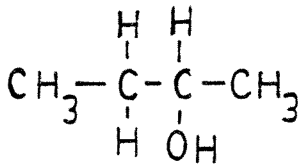
$CH_3 - O - CH_3$	methyl ether
$C_2H_5 - O - C_2H_5$	ethyl ether
$CH_3 - O - C_2H_5$	ethyl methyl ether

The ethers of low molecular weights are colorless, neutral liquids, more volatile than the corresponding alcohols and lighter than water. They are very stable and inactive and, therefore, used as solvents. The ethers, especially the lower members are highly inflammable.

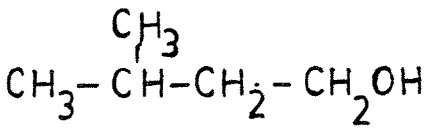
ALCOHOLS I



CH_3-OH	methanol	
$CH_3 - CH_2OH$	ethanol	
$CH_3 - CH_2 - CH_2OH$	propanol	1.
$CH_3 - CHOH - CH_3$	propanol	2.
$CH_3-CH_2 - CH_2 - CH_2OH$	butanol	1.
$CH_3 - CH_2 - CHOH-CH_3$	butanol	2.



$(CH_3)_2- CH - CH_2 - CH_2OH$ methyl butanol



$CH_3 - (CH_2)_{28}- CH_2OH$ myricyclic alcohol

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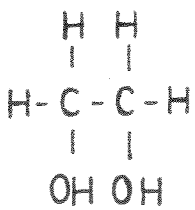
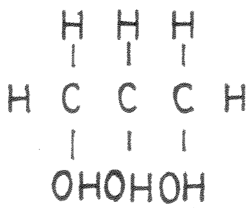


ETHANEDIOL

or

GLYCOL



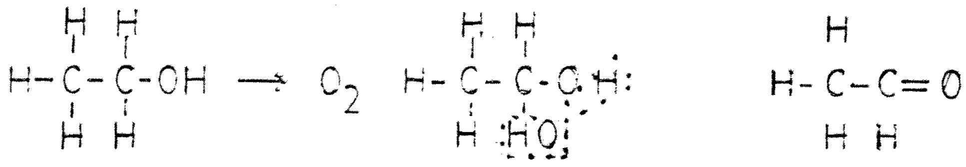
PROPANETRIOL

or

GLYCEROL

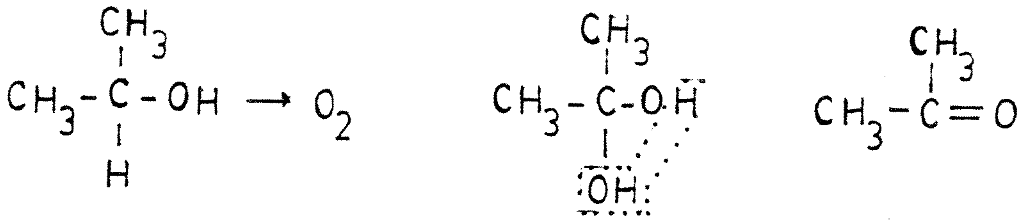
ALCOHOLS 2

PRIMARY ALCOHOL (OH attached to an end C, all the other C has H)



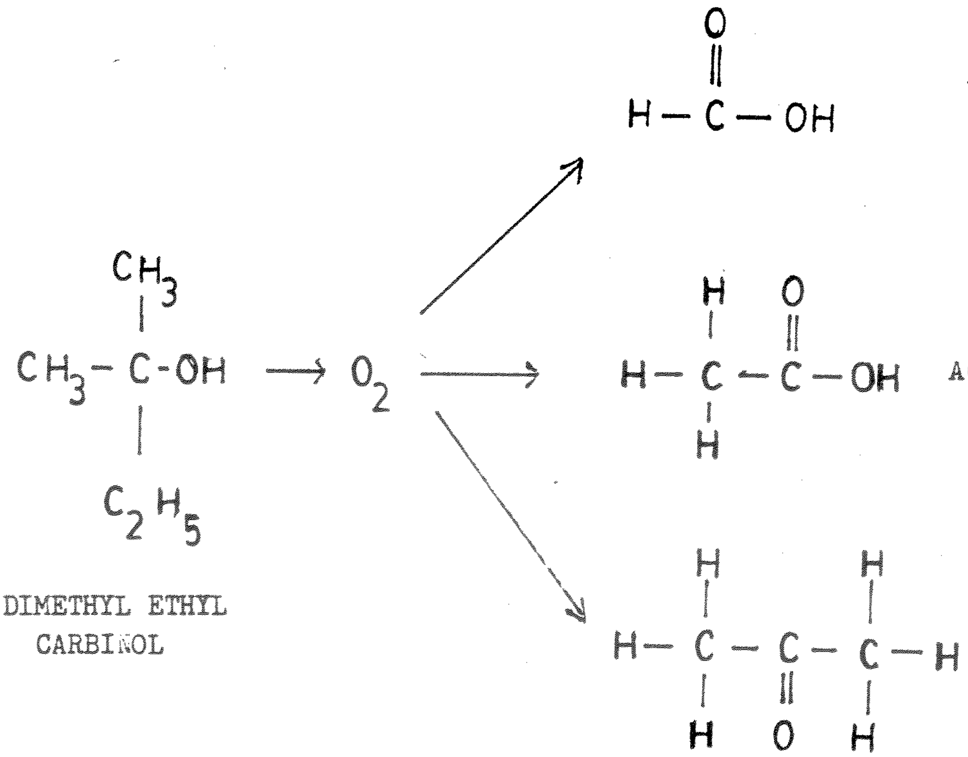
ETHANOL unstable ACETALDEHYDE

SECONDARY ALCOHOL (OH group attached to a C which has only one H)



ISOPROPANOL unstable ACETONE

TERTIARY ALCOHOL (OH group attached to a C all other bonds attached to other carbons)



FORMIC ACID

ACETIC ACID

DIMETHYL ETHYL CARBINOL

ACETONE

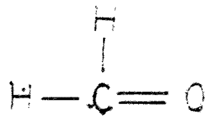
+ CO_2 and HOH

ALCOHOLS 3

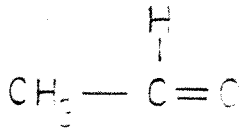
GROUPS DERIVING FROM:

ALCOHOL	R - OH	
ALDEHYDES		$R - \overset{\overset{\displaystyle O}{\|}}{C} - H$
KETONES	$R - \overset{\overset{\displaystyle O}{\|}}{C} - R$	
ACIDS	$R - COOH$	$R \; C \begin{smallmatrix} \diagup\!\!\!\!= O \\ \diagdown OH \end{smallmatrix}$
ESTERS	(alcohol + acid)	
	CH_3COOR	
ETHERS	$R - O - R$	

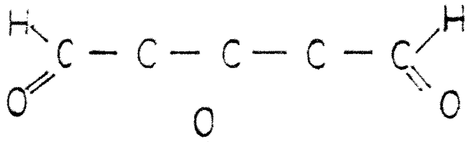
ALDEHYDES



FORMIC ALDEHYDE
or
FORMALDEHYDE

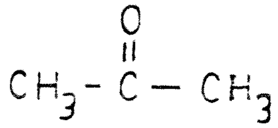


ACETIC ALDEHYDE

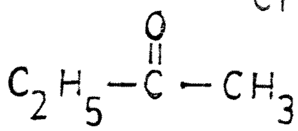


GLUTARALDEHYDE

KETONES

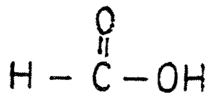


DIMETHYLKETONE
(acetone)

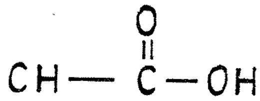


ETHYL METHYL KETONE

ACIDS



FORMIC ACID



ACETIC ACID

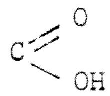
ETHERS

CH_3-O-CH_3 METHYL ETHER

$C_2H_5-O-C_2H_5$ ETHYL ETHER

$CH_3-O-C_2H_5$ ETHYL METHYL ETHER

XI. ORGANIC ACIDS

Organic acids contain the carboxyl group COOH 

and may be considered as hydrocarbon in which one or more hydrogen are replaced by COOH group.

CH_4 or CH_3H CH_3COOH

If the compound contains one COOH group it is known as monobasic, if it contains two COOH, it will be dibasic, Three tibasic etc.

The organic acids are named from their hydrocarbon derivatives by changing the end e in oic

methane	methanoic acid
ethane	ethanoic acid etc.

But, the most common acids have names that suggest their origin

formic acid	from	"formica" ants
butyric acid	from	butter
lactic acid	from	milk
palmitic acid	from	palm oil

Many of the monobasic acids contain fats or are formed from fats on hydrolysis and are called therefore FATTY ACIDS.

THE lower members up to $C_9H_{19}C$ OOH are liquids with strong odors, the higher ones are waxy solids.

High molecular weight fatty acids give esters with alcohols, those esters are the constituants of fats.

Most of the fats predominating in the nature are liquid, those liquid fats can be hardened by hydrogenation (adding of hydrogen) ex. peanut oil in peanut butter

When a fat is treated with NaOH or KOH, the ester is hydrolysed and becomes a soap, this is known as SAPONIFICATION.

Glyceril palmitate + NaOH Glycerine + sodium Palmitate

ORGANIC ACIDS

$H\,COOH$	methanoic acid or formic acid
$CH_3\,COOH$	ethanoic acid or acetic acid
$C_3H_6O_2$ or $C_2H_5\,COOH$	propanoic acid or propionic acid
$C_4H_8O_2$ or $C_3H_7\,COOH$	butyric acid
$C_{12}H_{24}O_2$ or $C_{11}H_{23}\,COOH$	lauric acid
$C_{16}H_{32}O_2$ or $C_{15}H_{31}\,COOH$	palmitic acid
$C_{17}H_{34}O_2$ or $C_{16}H_{33}\,COOH$	margaric acid
$C_{18}H_{36}O_2$ or $C_{17}H_{35}\,COOH$	stearic acid
$C_{20}H_{40}O_2$ or $C_{19}H_{39}\,COOH$	arachic acid

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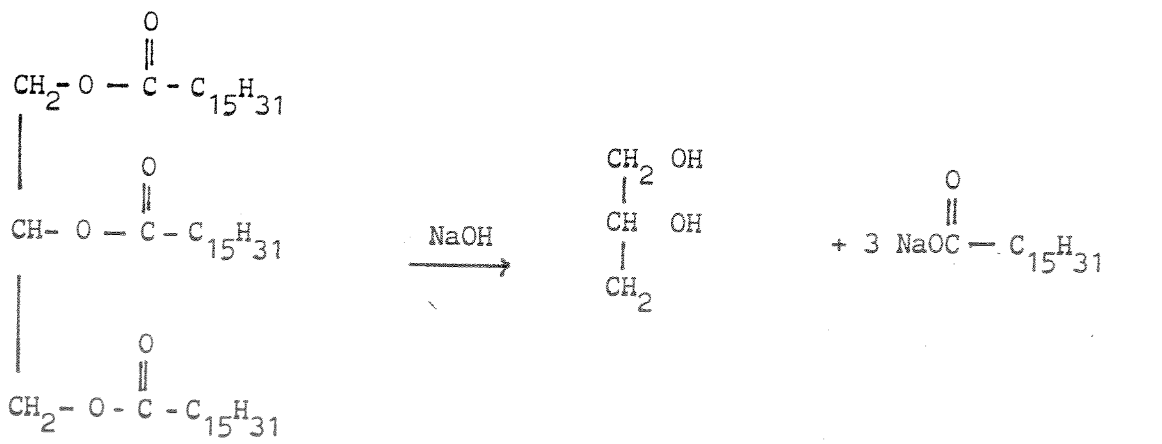


Glyceril palmitate glycerine sodium palmitate

****

$$RCOOH \xrightarrow{H_2} RCH_2\,OH \xrightarrow{Na_2SO_4} RCH_2\,OSO_2\,ONa$$

XII. AMINES

The amines are the bases of organic chemistry, they have the type formula $R - NH_2$

They may be considered as derived from ammonia NH_3 in which one of the hydrogens is replaced by an alkyl group.

CH_3NH_2	methyl amine	$C_2H_5NH_2$	ethyl amine
$CH_3NH - CH_3$	dimethylamine	$\begin{array}{l} CH_3 - N - CH_3 \\ \quad\;\;\; \vert \\ \quad\;\; CH_3 \end{array}$	trimethylamine

Amines have a strong fish-like odor

are more basic than ammonia
are soluble in water
form salts with acids

AMINO ACIDS

An amino acid is a compound in which one of the hydrogen in one of the carbon atoms adjacent to the carboxyl group is replaced by a amino group:

acetic acid	amino acetic acid
$\begin{array}{l} CH_2 - COOH \\ \vert \\ H \end{array}$	$\begin{array}{l} CH_2 - COOH \\ \vert \\ NH_2 \end{array}$

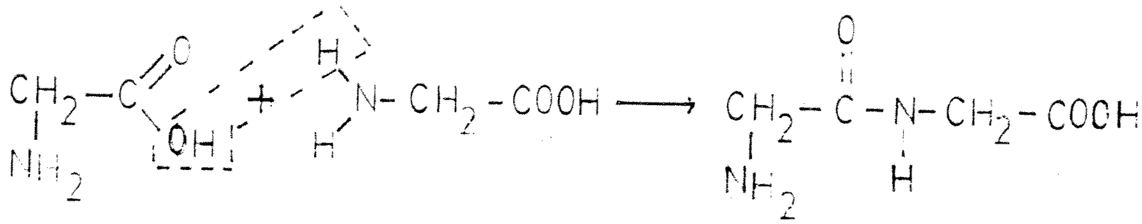
In the amino acids both of acid and basic groups coexist, that is the carboxyl group and the amino group. Thus, they may act as acids or bases depending on the conditions.

The amino acids are the compounds, which through our arteries and veins, are carried to the various portions of our bodies where they are converted into tissues, muscular and collagen fibers, etc. as needed.

Amino acids combine in various groupings to form PROTEINS

$$R - CH \begin{array}{l} \diagup NH_2 \\ \diagdown COOH \end{array}$$

The exact manner in which they combine is not well known, but it is believed to be through their active carboxylic and amine groups by what is known as the PEPTIDE linkage.



Among the three classes of food stuffs : simple fats, carbohydrates and proteins, the proteins alone contain the element nitrogen.

The proteins are important constituents of our foodstuffs.

The food proteins are hydrolysed in our digestive system to about 20 different amino acids and recombined in body proteins.

In the skin, there are two types of proteins : the fibrous and the globular proteins.

The fibrous proteins are the collagen, the keratin (hair) and the elastine. They are large molecular weight materials insoluble in neutral solvents or slightly acid or alkaline solutions.

The globular proteins are non-fibrous in nature and are soluble in above solvents. It has recently believed that globular proteins may be the building blocks of fibrous proteins.

XIII. CARBOHYDRATES

As the name indicates, the members of this group are made up of carbon hydrogen and oxygen, where hydrogen and oxygen are present in the proportion 2 : 1 just as in water.

The carbohydrates fall into two main classes:

1. the sugars - sweet crystalline compounds

2. the starches and celluloses - tasteless non-crystalline compounds

Starch occurs in plants (seed, fruit, tubers, roots). It can be separated in two components, one water soluble component: amylum and one water insoluble component : amylopectine. The later can be used in formulation of adhesives.

Cellulose is found in the cell walls of plants and gives them necessary rigidity.

The reaction of cellulose with sodium hydroxide and methyl or ethyl chloride gives methyl or ethyl cellulose used in the paper and the adhesive industry.

Cellulose treated with nitric acid gives explosives (guncotton)

Only partly nitrated it makes pyroxylin and is used for lacquers and plastics (nitrocellulose - celluloid)

Treated with acetic acid, we become Cellulose acetates, which give acetate rayon or viscose rayon for threads or cellulose acetate films (non flammable).

XIV. AROMATIC HYDROCARBONS

We have seen that Methane CH_4 is the smallest possible hydrocarbon of the aliphatic serie and that it is considered the mother compound of the serie.

In the same manner, benzene is the smallest compound in the aromatic serie and is the mother compound of that serie.

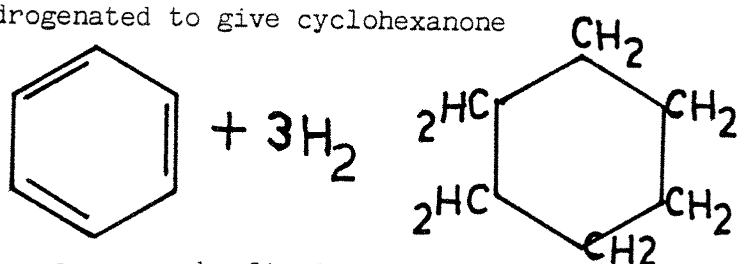
Benzene has the formula C_6H_6 in a ring structure.

As Carbon must maintain its valence of 4, there are in benzene three unsaturated or double bonds.

In the aliphatic serie, unsaturated bonds are very reactive and addition to the double bond is quite simple and rapid. In the case of benzene however the double bonds are less reactive and need forced conditions to react (pressure, high temperature, sometimes a catalyst)

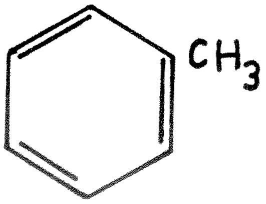
But most of the reaction we have seen up to now are possible and the nomenclature added to the parent name will be similar.

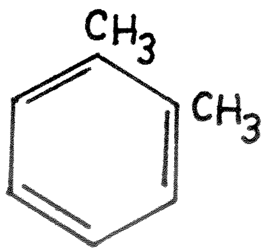
Benzene can be hydrogenated to give cyclohexanone



One or more methyl groups can be fixed on benzene to give toluene or xylenes

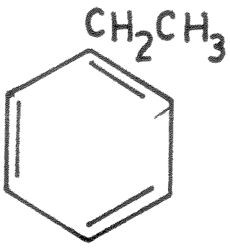
$C_6H_5CH_3$



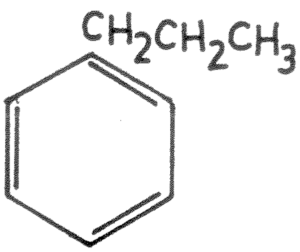


$C_6H_4(CH_3)_2$

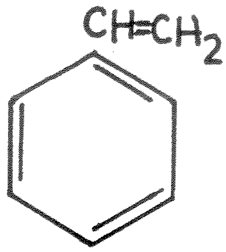
Ethyl or other alkyl groups can be fixed to give the corresponding compound



ethyl
benzene

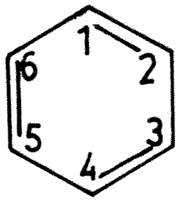


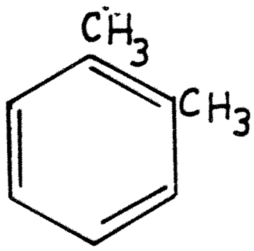
propylbenzene



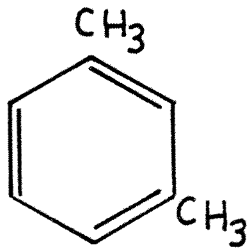
styrene

Isomerism will also occur.

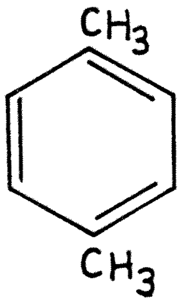




o - xylene
ortho

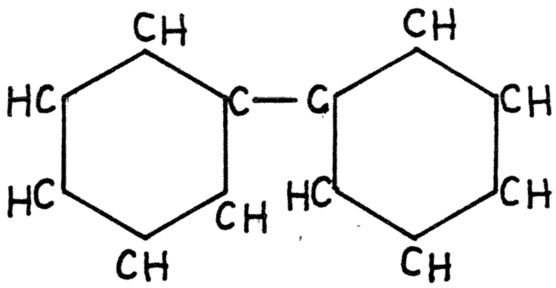


m - xylene
meta



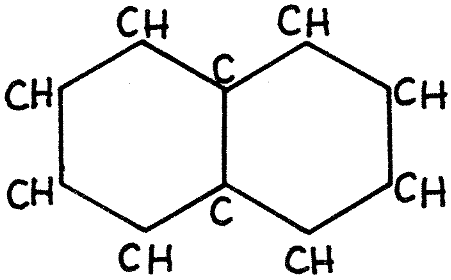
p-xylene
para

Two or more benzene rings can link together

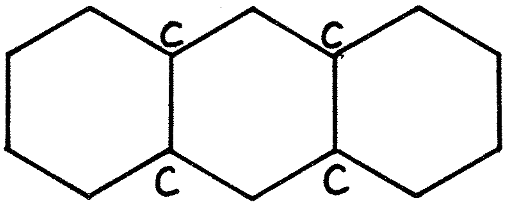


biphenyl

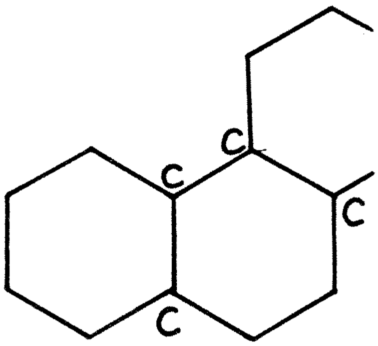
or fuse together



naphtalene



anthracene



phenantrene

Three reactions are peculiar to aromatic chemistry:

1. sulfonation

   SO_3H

2. nitration

   NO_2

3. oxydation O_2

The combination of these three reactions is at the origin of many industrial chemicals, namely, the aminoplast for the plastic industry, resins and synthetic tannins, dyestuffs.